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OPERATING EXPERIENCE WEEKLY SUMMARY

Office of Nuclear and Facility Safety

February 20 through February 26, 1998

Summary 98-08

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EVENTS

1. SEVERE WEATHER, EMERGENCY RESPONSE ACTIONS, AND OPERATIONAL SAFETY REQUIREMENTS

On February 17, 1998, at the Oak Ridge Y-12 Nuclear Operations Facility, a severe thunderstorm occurred during a loss of power to buildings and forced personnel to assemble inside, although the operational safety requirements required them to evacuate because power was lost to the criticality accident alarm system. Based on a National Weather Service severe thunderstorm warning, the plant shift superintendent made a plant-wide announcement restricting outside work and travel and directed personnel to seek shelter inside. The severe weather lasted for a period of 1 hour and included hail, high winds, and deadly lightning. Facility personnel obtained audible personal radiation detection devices and remained at their designated internal assembly points until the National Weather Service lifted the storm warning. This event is significant because emergency response to severe weather conditions contradicted the operational safety requirement actions. (ORPS Report ORO--LMES-Y12NUCLEAR-1998-0013)

Following the loss of normal power to the buildings, the facility managers declared the criticality accident alarm system inoperable. Facility personnel used audible personal radiation detection devices so they could remain inside the buildings. The detection devices would have alarmed, providing a warning of an inadvertent criticality. After the weather front passed, maintenance crews began to troubleshoot the cause of the power loss. They discovered that a flock of birds had flown into a transformer bay and had caused a short circuit in the transformer. The maintenance crew restored normal power to the buildings, and technicians tested the criticality accident alarm system. There were no personnel injuries, minimal facility damage, and no environmental concerns associated with this weather front.

Following a fact-finding meeting, the DOE facility representative raised the concern that the operational safety requirement did not address “shelter in place” during the loss of the criticality accident alarm system and that the operational safety requirement had been violated. Meeting attendees all acknowledged that the actions taken by facility personnel were appropriate regarding “shelter in place” and the use of audible personal radiation detection devices because of severe weather conditions.

This event underscores the importance of understanding that operational and technical safety requirements may not address every situation, particularly during emergencies. Facility managers must weigh the risks of personnel injury presented by various hazards, such as inadvertent criticality, fire, chemical or radiological release, hail storms, and dangerous lightning. Contingencies should be considered for evacuation routes and assembly locations, as well as the availability of personnel protective equipment. During a loss of power, warning systems, alarms, and notification systems may not be available. Immediate and actual hazards to personnel safety should take priority over potential hazards, even if actions outside the operational safety requirements must be taken.

DOE O 5480.22, *Technical Safety Requirements*, Attachment 1, item 3, “Conditions Outside TSR,” states that in an emergency, if a situation develops that is not addressed in the technical safety requirements, site personnel are expected to use their training and expertise to take actions to correct or mitigate the situation. Also, site personnel may take actions that depart from the technical safety requirements provided that (1) an emergency exists, (2) these actions are needed immediately to protect the public health and safety, and (3) no action consistent with the technical safety requirements can provide adequate or equivalent protection.

KEYWORDS: criticality alarm, emergency, evacuation, lightning, storm, weather

FUNCTIONAL AREAS: Emergency Planning, Licensing/Compliance, Nuclear/Criticality Safety

2. IMPROPER ELECTRICAL INSTALLATION RESULTS IN SHORT CIRCUIT

On February 18, 1998, at the Weldon Spring Site, a construction engineer observed sparks coming from a wiring trough (gutter) in an electrical panel when he energized the main disconnect to test-run a newly installed electrical system for pumps at a retention pond. He immediately opened the main switch and contacted safety and electrical personnel. A cut insulating tape on a wiring bundle caused a short circuit when the construction engineer energized the 480-volt system. Investigators determined that the construction engineer energized the panel before electricians finalized tests that could have identified the damaged bundle. Although there were no injuries, the failure to perform electrical testing and inspections presented an electrical safety hazard. (ORPS Report ORO--MK-WSSRAP-1998-0005)

Electricians verified that the electrical system was de-energized and the main disconnect switch was open and locked out before inspecting the electrical panel. They discovered the damaged insulating tape and observed approximately ¼ inch of water in the wiring trough enclosure. The water entered the enclosure through the conduit connectors that run between the pump and the main disconnects. Investigators believe a subcontractor accidentally cut through the insulating tape, which covered a 3-wire termination, when he closed a hinged cover during installation. The insulated wire bundle was bulky and fit tightly inside the wire trough; thus, additional care was required when closing the cover. Investigators also determined that the subcontractor failed to install rain-tight washers or National Electrical Manufacturer’s Association (NEMA) 3R fittings. Although the water intrusion may not have contributed to the electrical short in this event, corrosion or an electrical short circuit could have caused later problems.

The Project Management Contractor held an incident review meeting. Attendees determined that electrical personnel did not release the electrical panel because they had not performed final inspections and testing, which included testing with a 1,000-volt megger. Attendees also determined that a communication breakdown between the installation subcontractor and the construction engineer over the availability of electrical power and the need for operational pumps at the retention pond were causal factors. The installation subcontractor will take the connectors apart, re-tape them, and install the rain-tight fittings between the gutter and disconnect switches. Project Management Contractor electrical personnel will perform a surveillance of other, similar on-site electrical systems to ensure they have water-tight connections.

Water intrusion into electrical equipment can result in equipment damage, electrical outages, and disruption of facility operations. NFS has reported other water-intrusion events in the Weekly Summary. Following are some examples.

- Weekly Summary 98-06 reported that rainwater leaked into a breaker at the Sandia National Laboratory causing a power outage. Investigators determined that a roof gutter diverted rainwater directly onto a breaker enclosure that had conduit penetrations in the top. They also determined that the enclosure was designed for indoor use. (ORPS Report ALO-KO-SNL-NMFAC-1997-0007)

- Weekly Summary 97-32 reported that water backed up in an abandoned drain line into a 13.2-kV transfer switch at the Los Alamos National Laboratory causing a short circuit. The loss of power throughout the facility had a financial impact in excess of $40,000. (ORPS Reports ALO-LA-LANL-HRL-1997-0001, ALO-LA-LANL-TA55-1997-0032, and ALO-LA-LANL-CMR-1997-0010)

- Weekly Summary 97-25 reported that rainwater leaked into a fire alarm panel at the Idaho National Engineering Laboratory, resulting in the failure of interior circuit boards. The fire alarm panel is safety-significant equipment designed to report system trouble to the fire department's alarm room. (ID--LITC-LANDLORD-1997-0008)

- Weekly Summary 96-24 reported that a 13.8-kV circuit breaker at the Oak Ridge National Laboratory tripped because 35 gallons of water accumulated in the primary bus compartment of a transformer, causing a ground fault. The resulting power outage caused a reactor scram at the High Flux Isotope Reactor and an evacuation at the Radiochemical Engineering Development Center. (ORO--ORNL-X10PLEQUIP-1996-0007)

This event illustrates the importance of ensuring that equipment has been officially released for use and that all required inspections and testing are performed. Inspectors would have identified the missing water-tight fittings and, coupled with testing, may have found the damaged insulating tape. The installation subcontractor should have recognized that extra care may be required when closing the cover because of the full wiring trough. Also, crafts people should evaluate the quality of their work after completion of the job and ensure that everything was performed in accordance with the work instructions and applicable codes.

This event also points out the importance of preventing water intrusion into electrical equipment. The integrity of outside enclosures requires installation of rain-tight fittings and seals at penetrations. Information on outdoor equipment can be found in the National Fire Protection Association Standard, NFPA 70*, National Electrical Code;* NEMA Publication 250, *Enclosures for Electrical Equipment;* and NEMA Standard ICS 6*, Industrial Control and Systems Enclosures.* Additional information on NEMA electrical standards is available at URL http://www.nema.org/nema/standards.

KEYWORDS: electrical maintenance, inspection, short circuit, test, water

FUNCTIONAL AREAS: Electrical Maintenance, Construction

3. BERYLLIUM OXIDE EXPOSURE

On February 12, 1998, at the Lawrence Livermore National Laboratory, a facility supervisor reported that a researcher was potentially exposed to airborne beryllium oxide when he brushed a laboratory table with his hand to demonstrate that the material would not become airborne. The researcher incorrectly believed the material was aluminum oxide. When he realized that the material was beryllium, he called Health Services personnel for assistance, and they directed him to shower as a precautionary measure. An industrial hygienist sealed the room to contain any airborne beryllium. Health Services personnel took nasal swipes from the researcher and surveyed the room and adjacent areas. They determined that no beryllium was present on the nasal swipes. However they found beryllium contamination on the laboratory room floor and low-but-detectable levels in an adjoining hallway. Because investigators determined that the beryllium oxide ceramic had been on the laboratory table for several weeks, Hazards Control personnel checked the researcher's car and home as a precaution. No beryllium contamination was found. Exposure to low levels of beryllium can cause chronic beryllium disease, which can be fatal to individuals who are particularly susceptible to this disease. (ORPS Report SAN--LLNL-LLNL-1998-0012)

Investigators reported that the supervisor entered the laboratory and observed a torn bag and pieces of material spread on a laboratory work table. The supervisor believed the material was beryllium oxide ceramic, so he contacted facility personnel to assess the situation and met with the researcher to discuss the material. The researcher then went to another laboratory, retrieved a bagged sample of beryllium oxide, compared it to the material on the laboratory table, and determined that it was beryllium oxide.

Investigators determined that the worker had taken beryllium training and had worked with beryllium previously. Health Services and Hazards Control personnel are evaluating other facility personnel who accessed the laboratory room over the last several months to determine if any of them were exposed to beryllium oxide. The facility manager formed an incident analysis team to investigate this event. The incident analysis team will continue to investigate this event to determine (1) why the researcher believed the material was aluminum oxide, (2) why the beryllium oxide ceramic was in the room, (3) why the researcher did not initially recognize it was beryllium oxide ceramic, and (4) what administrative and supervisory controls were in place to control beryllium.

NFS has reported beryllium exposures in the following Weekly Summaries.

- Weekly Summary 95-19 reported that four experimenters at the Brookhaven National Laboratory Alternating Gradient Synchrotron Facility were exposed to Osmium-185 and Beryllium-7 when a beam target broke during a high intensity experiment. (ORPS Report CH-BH-BNL-AGS-1995-0002)

- Weekly Summary 93-37 reported that health physics personnel at the Los Alamos Meson Physics Facility determined that 11 workers received beryllium-7 uptakes while performing replacement of an accelerator target. (ORPS Report not available)

The Environmental Protection Agency classifies beryllium oxide as a special health hazard substance because it is a carcinogen. Beryllium oxide is a white, odorless powder that is used in ceramics, glass, electron tubes, electronic components, nuclear fuels, and nuclear moderators. Beryllium oxide inhalation can lead to chronic beryllium disease. According to the Environmental Protection Agency, chronic beryllium disease is irreversible and can produce the following effects.

- High exposures of beryllium oxide usually result in severe bronchitis or pneumonia, within 1 to 2 days after exposure, accompanied by fever, cough, and shortness of breath.

- High exposures of beryllium oxide can result in death.

- High or repeated low exposures of beryllium oxide can scar the lungs and other organs. Fatigue, weight loss, shortness of breath, lung damage, and heart failure can occur years after the exposure.

- Exposure to beryllium oxide can cause an allergic skin rash.

- High or repeated beryllium oxide exposures can cause kidney stones.

Additional information about the clinical characterization of chronic beryllium disease can be found in the *Defense Programs Beryllium Good Practice Guide* and in DOE G 441.1-7, *Implementation Guide for use with DOE N 440.1, Interim Chronic Beryllium Disease Prevention Program*. These documents state that chronic beryllium disease is characterized by pulmonary symptoms that include dyspnea, non-productive cough, and deterioration in lung functions. Symptoms also can include progressive weakness and fatigue, pain, and anorexia. Some public health practitioners believe there may be no safe level of exposure to beryllium oxide, so all exposures should be reduced to the lowest possible levels. Individual susceptibility may play a role in who does or does not develop chronic beryllium disease. This may account for the development of the disease in individuals with low or seemingly inconsequential exposures. The following are workplace exposure limits for beryllium oxide from several sources. However DOE adheres to the limits of the Occupational Safety and Health Administration or the American Conference of Governmental Industrial Hygienists, whichever is lower.

- Occupational Safety and Health Administration, 29 CFR 1910.1000, “General”—The legal airborne permissible exposure limits are 2 $\mu g/m^3$ averaged over a 8-hour work shift of a 40-hour work week; 5 $\mu g/m^3$ as an acceptable ceiling during an 8-hour work shift; and 25 $\mu g/m^3$ as a maximum peak above the acceptable ceiling concentration, which is not to be exceeded during any 30-minute work period for beryllium and beryllium compounds.

- National Institute for Occupational Safety and Health—The recommended beryllium airborne exposure limit is 0. 5 $\mu g/m^3$; it should not be exceeded at any time.

- American Conference of Governmental Industrial Hygienists—The recommended airborne exposure limit is 2 $\mu g/m^3$ averaged over an 8-hour work shift for beryllium and beryllium compounds.

These events illustrate the importance of controlling hazardous materials and point out that managers and supervisors must strictly enforce laboratory policies and procedures to prevent contamination and exposure. Facility personnel were not aware that the researcher had beryllium in the room, which emphasizes the need to establish and enforce strict controls when hazardous materials are introduced into a facility. Beryllium and other hazardous materials may also be encountered more frequently as DOE facilities transition to deactivation and decommissioning activities.

Managers and supervisors in charge of laboratories or facilities that handle beryllium should review the following documents to ensure that appropriate controls are in place and that employees adhere to them.

- DOE N 440.1, *Interim Chronic Beryllium Disease Prevention Program*, establishes a chronic beryllium disease prevention program to reduce the number of workers exposed, minimize exposure levels, and establish medical surveillance protocols. This notice also requires a training program for exposed and potentially exposed beryllium workers on (1) proper handling and control, (2) exposure hazards, and (3) controls and work practices (such as engineering controls, administrative controls, personal protective equipment, exposure minimization, medical monitoring, and waste management and decontamination procedures).

- Draft DOE G 441.1-7, *Implementation Guide for use with DOE N 440.1, Interim Chronic Beryllium Disease Prevention Program*, addresses beryllium, including (1) general information, (2) program elements for reducing and minimizing exposures, (3) programmatic considerations, (4) baseline inventories and sampling, (5) hazard assessments, (6) exposure monitoring, (7) specific exposure reduction and minimization guidance, (8) medical surveillance, (9) training, (10) record-keeping, and (11) performance feedback measures.

- National Institute for Occupational Safety and Health, *Criteria for a Recommended Standard Occupational Exposure to Beryllium*, provides criteria for the development of standards to prevent beryllium-related diseases. This recommended standard also includes information on beryllium properties, sources, and the biological effects of exposure.

- *Defense Programs Beryllium Good Practice Guide*, July 3, 1997, provides a program for controlling beryllium exposure. The guide includes information about (1) minimizing worker exposure, including during decontamination and decommissioning work; (2) controls for the handling of beryllium and its compounds; (3) medical monitoring and surveillance of exposed workers; and (4) site-specific safety procedures for beryllium processes.

Additional information on DOE beryllium worker protection activities can be obtained by calling the Office of Worker Protection and Hazards Management at (301) 903-6061. Information on the DOE Chronic Beryllium Disease Prevention Program and the documents referenced herein can be obtained at URL http://tis-nt.eh.doe.gov/be/. National Institute for Occupational Safety and Health information regarding beryllium can be obtained at URL http://www.cdc.gov/NIOSH/. The Rocky Flats Environmental Technology site has a beryllium information site at URL http://www.dimensional.com/~mhj/bsg/rfets.html. Lawrence Livermore National Laboratory also maintains a beryllium information site at URL http://www_training.llnl.gov/training/hc/Be/Be.html.

KEYWORDS: industrial hygiene, work control, work planning

FUNCTIONAL AREAS: Industrial Safety, Research and Development, Work Planning

4. RESPIRATOR T-BAR ASSEMBLY FAILS

On February 12, 1998, at the Hanford Site T-Plant Facility, a worker inside an airborne radiation area adjusted his respirator, and the assembly that holds the filter cartridges broke off in his hand. The worker held his breath and immediately exited the airborne radiation area. A radiation control technician surveyed the worker and found no detectable contamination. NFS reported on the same problem with the T-bar assembly in Weekly Summary 96-10, when this adapter broke on respirators at Hanford's PUREX, T-Plant, and Training Center facilities and at the Lawrence Livermore National Laboratory fire department. (ORPS Report RL--PHMC-TPLANT-1998-0005, RL--WHC-GENERAL-1996-0004)

Investigators reported that the worker was performing fire-watch duties wearing a Scott® O-Vista full-face respirator. The assembly broke at the connector where the T-bar connects to the body of the adapter. The manufacturer refers to this as a T-bar assembly. Investigators determined that the adapter broke at a degraded weld. The part number of the adapter that failed is 804251-01. Scott®, the manufacturer of the respirators, has developed an improved replacement part (part no. 804057-01). The Respiratory Protection Program coordinator issued site-wide instructions telling workers not to use Scott® O-Vista respirators with part no. 804251-01 pending further investigation. Scott® is currently re-designing the adapter and will make it available for purchase in approximately 6 months.

NFS reported other respiratory protection equipment problems in the Weekly Summary. Following are some examples.

- Weekly Summary 96-48 reported that safety personnel at Brookhaven National Laboratory discovered that a quick-operating connection on a face mask for a self-contained breathing apparatus failed during confined space training. The failure occurred inside the air mask at the air supply connection. (ORPS Report CH-BH-BNL-BNL-1996-0016)

- Weekly Summary 95-36 reported that maintenance personnel at Rocky Flats discovered deficiencies on four air line hoses while performing final checks of supplied-air respiratory equipment before entering a plutonium component storage area. One hose completely separated from the crimped fitting; the other three failed leak-test criteria. (ORPS Report RFO--KHLL-PUFAB-1995-0018)

- Weekly Summary 94-30 reported that the Nuclear Regulatory Commission issued an Information Notice on problems with inadvertent separation of the mask-mounted regulator from the facepiece on the Mine Safety Appliances Company self-contained breathing apparatus. (NRC Information Notice 94-35)

OEAF engineers searched the ORPS database for similar events and found three occurrence reports involving respirator design or material deficiencies. ORPS Report RL--WHC-PUREX-1995-0007 reported the same problem with Scott® respirators. ORPS Report RFO--EGGR-PUFAB-1992-0145 reported similar problems with cracked filter cartridge fittings on Welsh® full-face respirators. ORPS Report RFO--EGGR-371OPS-1993-0019 reported similar problems with cracked filter cartridge fittings on North® full-face respirators.

These events underscore the importance of carefully checking respirator condition and fit before entering areas where protection is required. A thorough check of equipment may reveal equipment defects. DOE/EH-0256T, *Radiological Control Manual*, part 3, "Respiratory Protection

Program," discusses equipment and requirements of respiratory protection programs and provides additional references.

For more information on the Scott® respirator adapter breakage, contact Cliff Ledford, Hanford Respiratory Protection Program Administrator at (509) 373-5214.

KEYWORDS: respirator

FUNCTIONAL AREAS: Industrial Safety, Radiation Protection

FINAL REPORTS

This section of the OE Weekly Summary discusses events filed as final reports in the ORPS. These events contain new or additional lessons learned that may be of interest to personnel within the DOE complex.

1. DROPPED FUEL-HANDLING BASKET

On January 8, 1998, at the Idaho National Engineering and Environmental Laboratory Chemical Processing Plant, fuel-handling operators dropped a basket of uranium-bearing material when the handling tool unexpectedly released the basket. The drop occurred while they were transferring the basket into a storage canister. The basket fell approximately 4 inches, then tipped over and landed in a horizontal position on the floor of the fuel-handling cave. Investigators determined that the handling tool probably failed to fully engage with the basket bail because design verification did not reveal that there were dimensional intolerances between the tool and the basket. There were no personnel injuries, and no radioactive material was released as a result of this event. (ORPS Report ID--LITC-FUELRCSTR-1998-0002)

Investigators determined that the handling tool used for the transfer was designed to automatically engage when lowered into the basket bail and was equipped with an indicator to allow the operator visual verification of tool engagement. Investigators also determined that the design engineers did not discuss the indicator and its function when briefing the Operations Training personnel. However, they did tell training personnel that the tool would either engage fully or would not engage at all.

The design engineering group performed a dimensional check of allowable design tolerances as part of the investigation. The handling tool is cylindrical and is designed to fit inside the slightly larger in diameter cylindrical basket bail. When they checked the design clearance between the handling tool and the basket bail, they determined that interference between the handling tool and the basket bail could have prevented full engagement if the tool was at the greater extreme of its allowable design dimensions and the basket bail was at the lesser extreme of its allowable design dimensions.

Facility managers determined that the direct cause of this event was that the handling tool failed to fully engage with the basket bail. They determined that a contributing cause was failure of the design engineers to inform Operations Training personnel that there was a positive engagement visual indicator on the handling tool. Facility managers determined that the root cause of this event was a design problem because designers did not allow for clearance between the handling tool and the basket bail if both parts were at their extreme allowable dimensional tolerances.

NFS has reported other events involving inadequate design review in the Weekly Summary. Following are some examples.

- Weekly Summary 97-35 reported a deficiency in the application of a hydrogen sensor at the Hanford Tank Farms. The sensor was not installed in a climate-controlled enclosure, and ambient temperature during the calibration was 20 to 30 degrees Fahrenheit. The manufacturer's specifications for the sensor required operating temperatures of 70 to 120 degrees Fahrenheit. Investigators determined that inadequate system design and design reviews resulted in the installation of equipment that could not reliably perform its safety function at low ambient temperatures. (ORPS Report RL--PHMC-TANKFARM-1996-0025)

- Weekly Summary 95-19 reported that radioactive contamination was released when a beam target broke during a high-intensity experiment at the Brookhaven National Laboratory Alternating Gradient Synchrotron Facility. Four experimenters received internal exposures. Investigators determined the design review associated with the experiment was inadequate. (ORPS Report CH-BH-BNL-AGS-1995-0002)

This event underscores the importance of engineers and system experts conducting thorough, adequate reviews of designs. Both 10 CFR 830.120 and DOE 5700.6C, *Quality Assurance,* discuss requirements for management assessment of quality processes. One of the elements discussed in these documents is design verification. This is defined as a formal documented process to establish that the resulting system, structure, or component will be fit for the intended use. This event also underscores the importance of clear communications. DOE-STD-1031-92, *Guide to Good Practices for Communications*, discusses the need for clear, formal, and disciplined communications and provides guides to improve communications.

KEYWORDS: communication, design deficiency, training program

FUNCTIONAL AREAS: Design, Training and Qualifications

2. MAINTENANCE FITTER CONTAMINATED

On December 8, 1997, at the Idaho National Environmental Engineering Laboratory, New Waste Calciner Facility, a maintenance fitter was contaminated after he removed his acid suit in a high contamination area. A radiological control technician measured 8,000 dpm beta/gamma on the fitter's knees, 3,200 dpm beta/gamma on his stomach, and 39,000 dpm beta/gamma on his modesty clothing. The fitter, a mechanic, and the radiological control technician had entered a decontamination cell to rebuild three remote valves. Facility personnel had flushed the valves before the re-build work began to reduce contamination levels and the amount of acid in the valves. Investigators determined that the fitter removed his acid suit during the job because of heat stress concerns. This allowed contamination to wick through his perspiration-soaked coveralls and contact his skin. Investigators also determined that exceeding heat stress stay-times contributed to this event. An incorrect interpretation of when the acid suit could be removed led to the fitter becoming contaminated and could have resulted in the contamination of additional personnel or the spread of contamination. (ORPS Report ID--LITC-WASTEMNGT-1997-0027)

Investigators determined that management problem (inadequate administrative control) was both the direct and root cause of this event. They determined the fitter was allowed to remove his acid suit because no one took into account that his clothing might be wet from perspiration. They also determined that he exceeded heat stress stay-times because of a misunderstanding. Investigators determined that residual amounts of flush water and contamination were expected during the valve work and that the radiological work permit required the maintenance workers to dress in modesty clothing, yellow nylon coveralls, Tyvek coveralls, an acid suit, and a full-face respirator. During the pre-job briefing workers were told they could remove their acid suits, after the valves were opened and the liquid hazard was eliminated, if they needed to reduce the potential for heat stress. Investigators determined that the work permit included a heat stress stay-time, but the workers believed it was only a guideline and the time could be exceeded if they felt physically capable of working longer. This misinterpretation led the fitter and a radiological control technician to exceed the heat stress stay-time.

The facility manager directed facility personnel to implement procedural changes for heat and cold stress stay-times. He also directed them to develop and implement a better method for evaluating personnel protective equipment requirements when working near contaminated surfaces. He directed industrial hygienists to reinforce the heat and cold stress stay-time requirements to facility personnel. In addition, he directed radiological control managers to develop a lessons learned document on similar contamination events that have occurred at Idaho National Engineering Environmental Laboratory and to include information from a Los Alamos National Laboratory report that summarized lessons learned from 68 similar events DOE-wide. The Los Alamos report (LA-13221-MS, *Radioactive Contamination Incidents Involving Protective Clothing*, October 1996) stated that all of the events shared five common characteristics. Following is a brief description of these characteristics.

- The events all involved maintenance-related work, usually with physically demanding work that required a lot of flexing or kneeling.

- The events all involved work performed in an adverse environment, such as cramped spaces or poorly ventilated areas, that caused workers to perspire.

- The workers in the events all wore the protective clothing required by radiological work permits and specified in pre-job briefs.

- A high percentage of the workers were contaminated on body areas that matched clothing stress areas; mostly, at the knee and forearm areas.

- The majority of these occurrences involved intact protective clothing or contamination that migrated through intact inner protective clothing with only the outer layer damaged.

The Los Alamos report determined that personnel protective equipment often fails to protect workers from contamination during demanding work conditions or when working in adverse environments. In addition, it states that multiple layers of clothing can make workers perspire, acting as a pathway for contamination. The report recommended that planners should consider better engineered controls (such as placing plastic sheets over contaminated areas) and more effective anti-contamination clothing (such as breathable, waterproof material). They determined that engineering controls and protective clothing may be effective options for managers who must balance costs, heat stress considerations, and contamination factors.

This event illustrates the need to effectively communicate personnel protective equipment requirements and job stay-times. In this event, the workers misunderstood the heat stress stay-time, which contributed to the worker's clothing becoming wet from perspiration and resulted in the fitter being contaminated. This event also illustrates the need to consider all hazards when determining the protective clothing requirements for a job performed in a contamination area. While wearing minimum protective clothing to reduce potential heat stress, workers could be exposed to increased contamination hazards. Heat stress stay-times protect workers from the physical effects of exposure to extreme temperatures. Stay-times are maximum limits that require an individual to leave a high temperature environment even though the individual may feel capable of continuing work. The physical effects of heat stress often give little warning to the individual; therefore, limits must be adhered so that worker protection is ensured.

Facility managers should review procedures for preparing work packages to ensure that the reviews are performed correctly and that changing environmental conditions are identified. They should also ensure that all work-related hazards are evaluated before work begins to reduce worker exposure to hazards and to prevent injuries.

- DOE 0 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*, states that the contractor must identify workplace hazards and evaluate the risk of associated worker injury or illness.

- DOE 4330.4B, *Maintenance Management Program*, section 8.3.1, provides guidelines on work control systems and procedures. The Order requires using control procedures to help personnel understand the requirements for working safely.

- DOE-STD-1050-93, *Guideline to Good Practices for Planning, Scheduling and Coordination of Maintenance at DOE Nuclear Facilities*, section 3.1.1.3, provides the key elements of an effective planning program. Included is guidance on consistency in planning between disciplines to avoid confusion and frustration of work groups. The standard also discusses the need for thorough reviews of work packages by experienced individuals to eliminate errors.

- DOE/EH-0256T, *Radiological Control Manual*, Table 3-1, provides guidelines for selecting the appropriate protective clothing. Chapter 3 of the manual provides guidance for proper personnel protective equipment and clothing. Chapter 5 discuss heat stress considerations and states that "supervisors should inform their personnel of heat stress precautions prior to work on job assignments in hot environments."

- The *Hazard and Barrier Analysis Guide*, developed by OEAF, discusses barriers that control job-associated hazards, such as physical barriers, procedural or administrative barriers, or human action. The reliability of a barrier is determined by its ability to resist failure. Barriers can be imposed in series to provide defense-in-depth and to increase the margin of safety.

The Los Alamos report can be found by accessing the Los Alamos National Laboratory online catalog at URL http://lib-www.lanl.gov. A copy of *The Hazard and Barrier Analysis Guide* is available from Jim Snell, (301) 903-4094. A copy may also be obtained by contacting the ES&H Information Center, (800) 473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Road, Germantown, MD 20874.

KEYWORDS: contamination, personal protective equipment

FUNCTIONAL AREAS: Radiation Protection, Industrial Safety